The Southern Plains Cyclone

A newsletter from your Norman Forecast Office for the residents of western and central Oklahoma and western north Texas

May 2010

Special Issue !

May 10th Tornado Outbreak

Also Featuring...

May 16th Oklahoma City Hailstorm

May 19th Tornado Outbreak

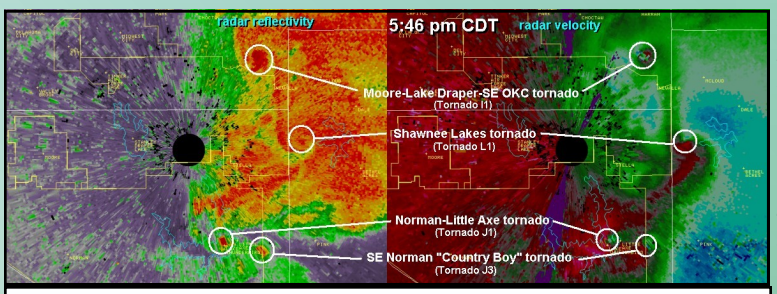
We Make the Difference...When it Matters Most!

May 10th Tornado Outbreak

By Doug Speheger

General Forecaster

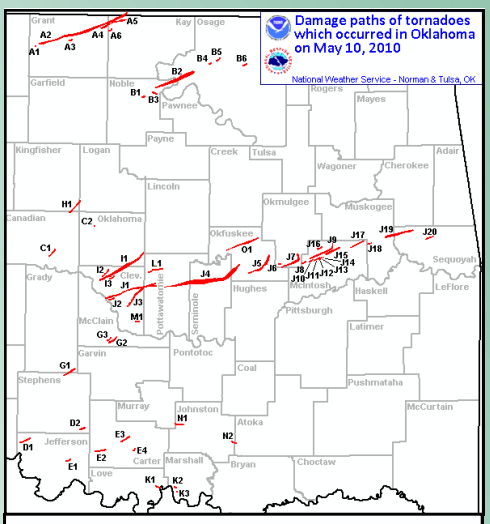
Tornado season started slowly in Oklahoma in 2010 with only three tornadoes through April, the fewest tornadoes in the first four months of a year since 1998. But in early May, meteorologists began noticing the potential for a significant tornado event to take place on May 10th. As early as the morning of May 4th, NWS Norman forecasters announced the potential for severe weather, and as May 10th approached, the forecast combination of instability and wind shear increasingly showed that severe weather and tornadoes were likely. By the time the day was over, 14 different thunderstorms had produced a total of 55 tornadoes in the state. May 10, 2010 became the 2nd largest outbreak recorded in Oklahoma, second only to the May 3, 1999 outbreak.



Reflectivity (left) and storm-relative velocity data from the central Oklahoma WSR-88D radar, KTLX, showing evidence of 4 tornadoes in progress within 20 miles of one another.

At 1:38 pm, the first radar echo appeared in northwest Oklahoma near Harmon. The storm gradually strengthened and produced hail up to the size of softballs near Cherokee. At 3:33 pm, the storm produced its first tornado southwest of Wakita. This tornado was small and brief, but minutes later another tornado formed that would continue for 41 miles as it tracked quickly from southwest of Wakita to north of Medford and Braman, eventually crossing into Kansas along at Interstate 35. At times, the storm produced other tornadoes at the same time that moved parallel to the large tornado. Meanwhile, a second storm developed to its south and produced 6 tornadoes across Noble and Osage Counties over an hour.

The storms that produced the greatest amount of damage and injuries formed in the mid to late afternoon across central and southern Oklahoma. Two storms began producing tornadoes at about the same time in central Oklahoma – one very-tilted tornado near Yukon and El Reno that many watched live on television, and another southwest of Cashion. Shortly after these tornadoes, there was a period of more than two and a half hours (from 5:00 pm through 7:41 pm CDT) during which there was at least one tornado occurring somewhere in Oklahoma at all times. During this incredible period, 33 different tornadoes affected the state, including 2 EF4 tornadoes that struck central Oklahoma. At one time, there were four tornadoes at once within about 20 miles of each other in Oklahoma, Cleveland and Pottawatomie Counties.



Tornadoes are named for their parent storm (letter) and the storm produced them (number). Varying line widths indicate the width of associated damage revealed by surveys.

The two most damaging tornadoes developed in Cleveland County. One formed within a few hundred yards of the National Weather Center, where the National Weather Service is located, in south Norman. Although it was relatively weak when forming near the National Weather Center, it strengthened significantly and produced extensive damage near Lake Thunderbird and the community of Little Axe. The other tornado formed in extreme north Norman, moved through south Moore and produced extensive damage near Stanley Draper Lake and in southeast Oklahoma City before dissipating near Harrah. Both of these tornadoes were rated EF4. Four EF3 tornadoes also occurred on May 10: from southwest of Medford to north of Braman in northern Oklahoma; near Shawnee Reservoir and from Tecumseh to Cromwell in central Oklahoma; and north of Lone Grove in southern Oklahoma.

Severe weather occurs frequently in Oklahoma and north Texas, but some outbreaks produce so many tornadoes over such a large area and in such a short time that they seem to be in a class of their own. It is on these days: May 25, 1955; June 8, 1974; April 26, 1991; May 3, 1999; May 10, 2010, and others, that we all need to share weather warnings and safety instructions with our friends and neighbors, and survive mother nature's worst - together.

More Online at:

http://www.srh.noaa.gov/oun/?n=events

May 10th - The Warning Before the Warning

By Patrick Burke

General Forecaster

When an outbreak of fifty-five tornadoes raced across Oklahoma on May 10, 2010, some people didn't know about it until the wind started to rattle their windows. Others knew this flurry of destructive weather was possible days earlier. How can you become one of those "in the know?" Check the weather forecast at least once each day, especially in the late winter and Spring.

Beginning in the late winter and continuing through the Spring the cold air created by winter climate drives strong jet stream winds and associated troughs across North America. Meanwhile, an increasingly high sun angle and longer days start to heat the ground. Water temperatures in the Gulf of Mexico rise and the landscape turns green with plant and tree life, two factors that lead to a significant step up in the amount of moisture in the air. It follows that the convergence of moisture, instability, and lifting mechanisms like troughs and fronts becomes much more common at that time of year. Tornado occurrence in Oklahoma and western north Texas is much higher from March through June than at other times of the year. And the occurrence of tornadoes, especially strong and violent tornadoes, peaks strongly in April and May.

So, knowing that severe storms and tornadoes are a frequent possibility, how do you find out whether they are going to affect your plans today? Or next week? The National Weather Service routinely issues a Hazardous Weather Outlook (HWO) that details the possible or expected impacts from all kinds of hazardous weather in the next one to seven days. The HWO is a great way for you to stay ahead of our often changing weather. The product is available in several ways through our web page, and an article explaining how to find it appears in the Spring 2010, issue of the Southern Plains Cyclone.

The tornado outbreak of Monday, May 10, 2010, was first mentioned as a possibility within the HWO and an associated graphical forecast issued the morning of Tuesday, May 4, a full six days in advance. A portion of the text read:

"…THERE ARE SOME INDICATIONS OF A POTENTIALLY SIGNIFICANT INCREASE IN THE RISK OF SEVERE WEATHER NEXT MONDAY."

This statement alone should tell you that it would be a good idea to check back for updated forecasts as Monday approaches. Because severe weather forecasting is not yet a precise science, there will usually be some uncertainty expressed, especially at longer lead times. But as an event approaches, observations, analysis, and numerical modeling, the tools of the trade, will lead forecasters to become more confident as to what kind of weather is most likely to occur. Sometimes that means the forecast risk of severe weather decreases, but on other occasions it increases. By watching the HWO evolve with each update, ask yourself, "Is the language become stronger and more certain." By Thursday, May 6, the HWO included a "Call to Action:"

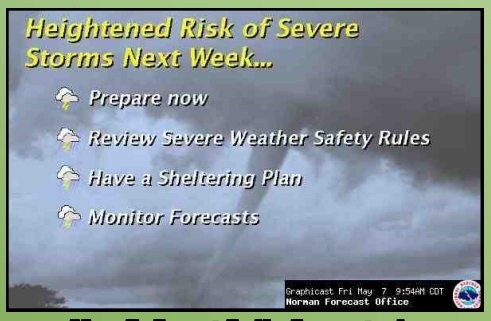
"EMERGENCY MANAGERS...STORM SPOTTER GROUPS...AND RELATED AGENCIES...AS WELL AS THE GENERAL PUBLIC...ARE ENCOURAGED TO PAY CLOSE ATTENTIONTO THE LATEST FORECAST INFORMATION THROUGH THE UPCOMING WEEKEND…"

By May 7, statements on the associated graphical forecast

Continued on page 3

Web-Based Graphicasts

May 4 - First Mention of Event



May 7 - Event Fully Expected... Focus Shifts to Safety Planning

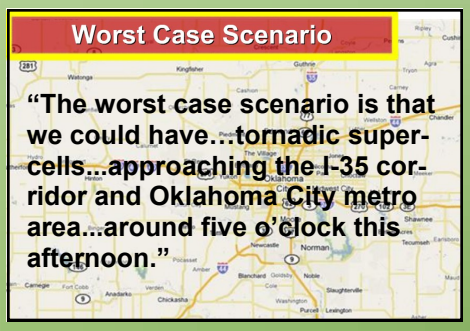
May 7 - Safety & Timing

May 10 - Strongly Worded Forecast

May 10th - The Warning Before the Warning

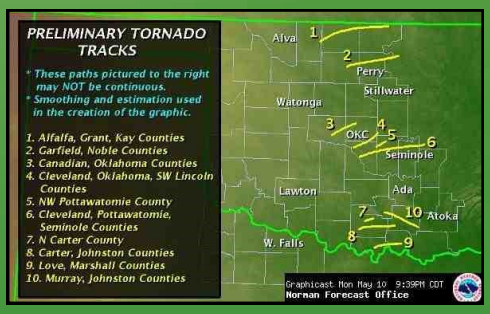
Web-Based Graphicasts

May 10 - Forecast Timing



May 10 - Multimedia Briefing 5 Hours Before Storms Struck Oklahoma City

May 10 - Damaging Tornadoes in Progress. Storm Scale Graphics Like These Were Updated 146 Times from 2:07 - 10:04 PM



May 10 - To assist media and government information outlets, this very preliminary tornado track map was issued before the last storm had ended that evening.

...continued from Page 2

had dropped the word "possible" in favor of the word "anticipated," meaning confidence was high that an event *would* occur. As is common leading up to severe weather events, the forecast "message" began to feature specifics about the expected storm type and movement, associated impacts, and actions people could take to prepare. The HWO, graphical forecasts, and multimedia briefings issued over the weekend of May 7-9, emphasized how storms would develop quickly and move very fast, and may produce significant tornadoes. The HWO issued Saturday evening, May 8, contained this statement:

"SEVERE THUNDERSTORMS ON MONDAY AFTERNOON AND EVENING MAY MOVE AT SPEEDS GREATER THAN 45 MPH… LEAVING LITTLE TIME FOR PEOPLE TO REACT TO WARNINGS. YOU ARE ENCOURAGED TO THINK AHEAD TO WHERE YOU WILL BE ON MONDAY...HOW YOU WILL RECEIVE WEATHER WARNINGS… AND WHERE YOU WILL SHELTER IF A STORM APPROACHES YOUR LOCATION."

In the 24 hours preceding the beginning of the tornado outbreak, the Norman Forecast Office issued six multimedia briefings, prominently displayed and easily viewable on our enhanced web page. Multimedia briefings consist of a National Weather Service Meteorologist speaking for 3 to 5 minutes with accompanying graphics. The presentations are intended for the general public as well as public officials, and use mainly plain or non-technical language. Feedback has been greatly positive. People tell us that when they see a multimedia briefing has been issued, they know the developing storm has potential to be "big."

The multimedia briefings issued on May 10, 2010, before the first radar echoes had been detected, outlined a possible worst case scenario that was growing increasingly likely. Tornadic storms were expected to move across heavily populated central Oklahoma, including Oklahoma City, during early evening rush hour traffic. Combine this with storm motions that were forecast at greater than 45 mph, and it was clear that simply being informed of a warning and then deciding where to shelter would be very risky. On a rare day like May 10th, it was important for people to think ahead and change their plans so that they would be close to an appropriate shelter during the hours when most people are leaving school or work by car.

Media partners helped to deliver this strong message to the public, and hopefully people acted more safely because of it. In a sense, within a few hours of the tornado outbreak forecasters thought the probability of strong tornadoes was so high that they did everything they could to "warn" the public well before issuing the product known as a tornado warning. That approach may only be possible or fitting when forecaster confidence is exceptionally high, as it was on May 10, 2010. By taking a few moments, however, to glance at a Hazardous Weather Outlook or listen to a multimedia briefing, you will find yourself prepared for severe weather long before the wind rattles the windows.

May 16th Oklahoma City Hailstorm

By Rick Hluchlan
University of Oklahoma
Graduate Student

On May 16th, 2010, a very damaging hailstorm affected much of Oklahoma City. A long-track supercell produced large and sometimes very large hail along a path more than 200 miles long, from Major County in northwest Oklahoma to Atoka County in southeast Oklahoma. The Oklahoma City metropolitan area was hit especially hard, not only because of the number of urban targets that could be damaged, but also because the storm was at its peak intensity during its trip from Kingfisher across northwest Oklahoma City to downtown. The storm seemed to produce more hail than rain, with most locations receiving at least golf ball size hail (1.75 inch diameter), and some receiving softball size hail (4.25 inch diameter). Winds of 50 to 60 mph accompanied the hailstorm, further enhancing widespread property damage to cars, homes, and vegetation.

The NWS defines softball-size hail as 4.25" diameter

While it was not clear a few hours beforehand that the atmosphere was about to unleash one of the costliest hailstorms in Oklahoma City's history, conditions were certainly favorable for severe weather. A weak warm front moved north across Oklahoma with dew points rising into the middle 60s and temperatures warming into the middle 70s south of the front. An upper level disturbance moving across the Southern Plains helped provide lift to initiate thunderstorms over northwestern Oklahoma. The storms then moved southeast while jet stream level winds increased from the northwest.

Extensive damage to a vehicle in Oklahoma City, caused by very large hail. Photo by Tim Marshall.

One large supercell thunderstorm developed along the warm front over Major County. The storm quickly became severe in the unstable environment, and baseball-size hail was reported west of Fairview. As the supercell moved southeast into Blaine County, it continued to intensify, producing softball-size hail near Okeene. The storm also produced golf ball to softball-size hail and several funnel clouds as it moved across Kingfisher and Canadian Counties.

The supercell thunderstorm responsible for the historic May 16, 2010, hailstorm that affected Oklahoma City. Roger Edwards pictured the storm from near Dale, OK, as it exited Oklahoma City.

By the time the supercell reached the northwest portions of Oklahoma City, it was producing winds of 60 mph while still producing softball-size hail. The storm maintained a steady course toward the southeast as it blasted through the Oklahoma City metropolitan area. Hail and wind-drive hail produced widespread major damage to cars, structures, and vegetation. Hail that lasted more than 10 minutes clogged storm drains and created local flooding. Hail drifts resembled snow drifts from the December 2009, blizzard, as hail piled up to several feet deep in some areas. Several locations reported hail on the ground for more than 12 hours after the storm ended.

Although golf ball-size hail was reported in Cleveland and Pottawatomie Counties, the storm was not as intense as it had been over Oklahoma City. Strong outflow from the supercell pushed well ahead of the storm. Reported hail sizes continued to shrink across Seminole, Hughes, Pontotoc, Coal, and Atoka Counties as the supercell dissipated.

For Oklahoma City, this was one of the costliest hailstorms in history, with damage estimates well into the millions of dollars. The fast moving storm occurred on a Sunday afternoon, catching many people off guard and outdoors during the worst of the storm. This event is yet another reminder to stay alert and be ready to take action during Oklahoma's quickly changing weather.

Historic Oklahoma City Hailstorms

By Patrick Burke
General Forecaster

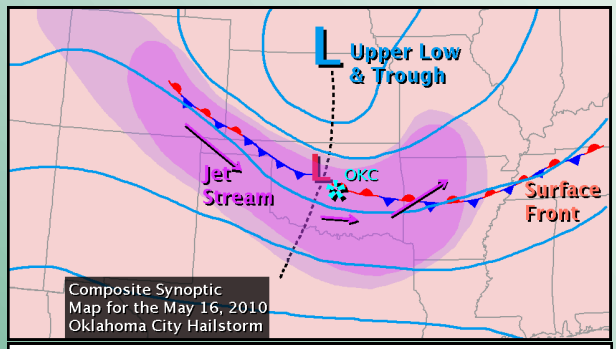
A quick search through the National Weather Service severe weather archive, Storm Data, shows us that the May 16, 2010, Oklahoma City hailstorm is in a rare class. Since 1950 there have been 68 storms that produced reports of 2-inch diameter hail in Oklahoma County (almost one per year), but only 10 storms that produced reports of 3.5-inch diameter hail or greater. The softball (4.25 inch diameter) hail that was reported in northwest Oklahoma City on May 16th this year was the third largest hail on record for Oklahoma County. On June 1, 1981, hail up to 4.00 inches in diameter struck Edmond, resulting in $7 to $10 million in damage. The Storm Data publication database lists hail of 5 inches in diameter reported in Oklahoma County on May 16, 1960 (exactly 50 years prior to this year's storm!), but details are unavailable.

> *"On May 26, 1963, hail of 2 to 4 inch diameter killed 10 or 12 calves and dented tin-roofed barns 4 inches deep."*

Falls of 4-inch diameter hail have been reported 7 times in Oklahoma County, including reports from Del City during the May 10, 2010, tornado outbreak. On May 26, 1963, hail of 2 to 4 inch diameter hit Del City/Midwest City and continued to the east. As part of the same cluster of storms, hail - in rural northwest Oklahoma County near Edmond - killed 10 or 12 calves and dented tin-roofed barns 4 inches deep. Of the ten storms that have produced at least 3.5-inch hail in Oklahoma County, four of them affected Edmond and three affected Del City/Midwest City.

On the calendar, most of these very large hail events took place between May 1st and June 19th. Interestingly, two events occurred in September. On September 6, 1992, a thunderstorm complex formed in northwest Oklahoma and moved southeast. Hail of 3.5-inch diameter was reported at Broadway and Britton in Edmond. This storm complex is remembered more for its destructive winds. At Max Westheimer Airport, winds estimated at 95 mph damaged or destroyed 22 of the 42 aircraft parked there. On Sep 22, 1985, very large hail in Oklahoma County was part of a remarkable outbreak of severe weather. One particular hailstorm tracked from Okarche to Cashion and Piedmont, producing golf ball to baseball size hail and $200,000 in damage at Piedmont. Presumably this same storm went on to produce hail up to grapefruit (4.00 inch) size in Edmond. That same day baseball size hail also fell in Moore and Norman and in northwest Oklahoma. Golf ball size hail, flooding, and 80 to 90 mph winds were all reported in southern Oklahoma.

A quick qualitative study of the weather maps associated with our 10 days producing 3.5-inch hail in Oklahoma City – suggests that key ingredients include strong instability and modest rather than strong lift, leading to isolated storm initiation. Most of these events were characterized by a relatively small upper level trough embedded in a strong westerly jet stream flow, atop a surface warm front. The westerly flow yields strong wind shear and cold air aloft. The surface warm front focuses moisture and convergent surface winds over Oklahoma, both favorable for getting severe storms started. With May 12, 1985, and September 22, 1985, being exceptions, the maps associated with these very large hail events differ from traditional severe weather outbreak patterns that usually include a large trough undergoing the transition to a mature extratropical cyclone. Again, these conclusions were drawn after only a cursory glance at the maps, but these ideas definitely deserve further study.



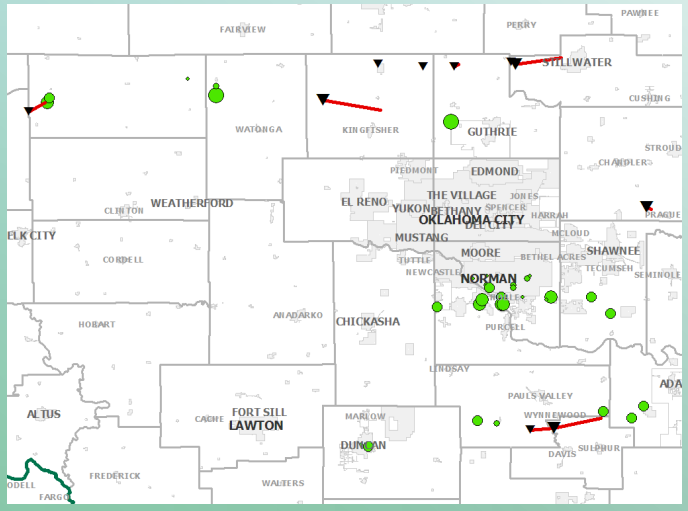
A warm front or stationary front, and low amplitude upper level trough embedded in a strong westerly jet stream appears to be common among several historic Oklahoma City hailstorms.

Finally, judging by the descriptions available for these events, it appears that May 16, 2010, could be the first time that a single, long-track supercell producing giant hail swept across the full length of Oklahoma County. The affected area was even maximized by the storm's moving diagonally from the northwest corner to the southeast corner of the County. This is not, however, the first such destructive and long lived storm to affect the Norman National Weather Service forecast area. One only has to look back to the Lahoma, Oklahoma, storm of August 17, 1994 (see the article in our Summer 2004 issue). Still, it is likely to be a very rare event to see such a prolific and long lasting hailstorm affect such a large swath of the Oklahoma City metropolitan area.

May 19th Tornado Outbreak

By Cheryl Sharpe
General Forecaster

The May 19th outbreak was not as strong or extensive as the May 10th event, but still managed to produce four EF1 tornadoes and numerous reports of large hail.



The map above shows reports of hail and tornadoes received by NWS Norman. Tornadoes are shown as black triangles, at the beginning of their paths, and again when entering a new county. The larger triangle represents an EF1 rating, and the smaller ones represent EF0. Red lines show the tornado tracks. The green circles are hail reports (larger circles = larger hail). The largest hail reported was 3.5 inches in diameter.

The first storm report was at 3:24 pm CDT in northwest Oklahoma, near Leedey, where a weak tornado occurred, but produced no damage. As the storms progressed east, they strengthened and encountered more populous areas, resulting in more reports — and more damage.

A tornado touched down in Kingfisher County at 5:33 pm CDT, and tracked east for 14 miles. It destroyed an unanchored trailer and a salt barn (Dept. of Transportation), blew a truck off US 81 (causing minor injuries to the driver), and caused other minor damage.

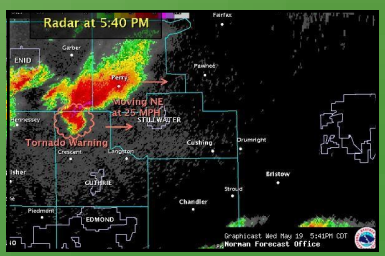
At 6:30 pm CDT another damaging tornado developed west of Stillwater. This storm mainly damaged outbuildings and trees.

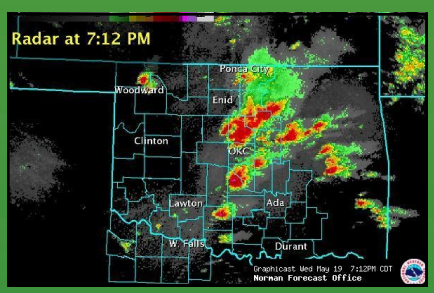
By 7:00 pm CDT a hailstorm arrived in the Norman area. Due to the relatively high population density, there were many reports of large hail as the storm tracked east across southern Norman and Noble. The storm finally moved east of Lake Thunderbird around 8 pm.

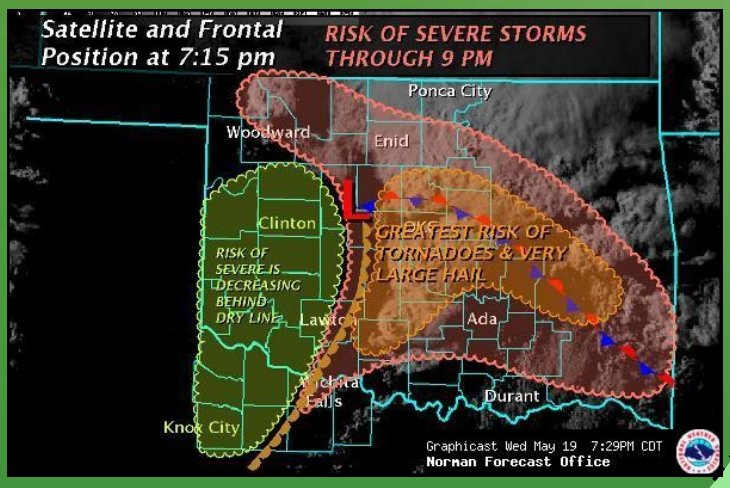
The last supercell of the day formed near Duncan, then moved east. It produced a tornado near Wynnewood, but damage was mainly concentrated in the Joy area. The tornado heavily damaged several barns and outbuildings, numerous trees, and power poles, and damaged a few roofs of homes.

All in all, there were five main supercell storms and at least nine tornadoes. Only three injuries resulted, and property damage was relatively light, given the number of storms. The brevity of most of the tornadoes, combined with the relatively lightly-populated areas that they affected, helped minimize the damage from these storms.

Storm Data for May 2010 (http://www.srh.noaa.gov/images/oun/pdf/stormdata/oun201005.pdf) was the source of the information presented in this article.







May 19th

Additional Services

NWS Norman:

- Issued multiple heads up e-mails to our local partners prior to the event, conducted several multimedia briefings, and held frequent coordination calls with local emergency managers.
- Participated on a conference call with the Oklahoma Department of Emergency Management Wednesday morning.
- Launched a special 1 PM balloon sounding to gauge changes in the atmosphere just prior to storm development.

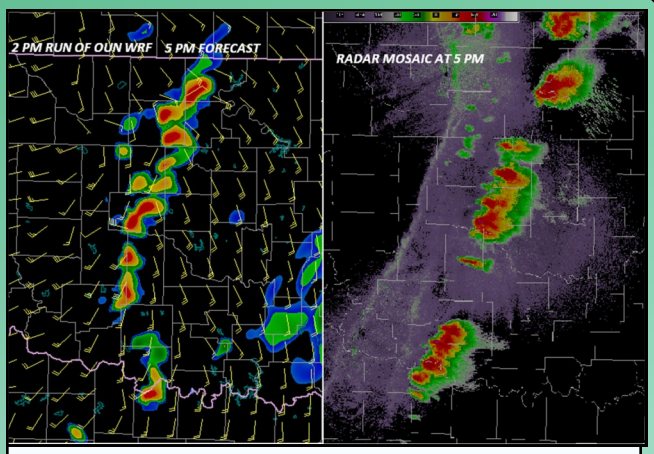
Warning Coordination Meteorologist... Rick Smith:

- Conducted multiple live video interviews with NewsOK.com.
- Provided 2 live phone interviews with the Weather Channel.
- Provided live weather radio broadcasts as storms approached Stillwater and Guthrie.
- Enhanced the routine Wednesday test of the NOAA All Hazards Weather Radio warning alarm tone. A live severe weather briefing that highlighted potential impacts.

Cutting Edge

Around noon on May 10th, NWS Norman began emphasizing the threat of tornadic supercells impacting Oklahoma City during rush hour traffic. Forecasts of storm existence, timing, and impacts were based in part on a local version of the Weather Research and Forecasting (WRF) model run at NWS Norman (see "High Resolution Modeling at WFO Norman" in the Spring/Summer 2008 issue). Model output performed exceptionally well in forecasting the timing, location and configuration of storms as they might appear in radar data.

The local model output gave forecasters ample reason, in collaboration with the Storm Prediction Center, to draw a tornado watch southward to the Red River, foregoing concerns that a cap would prevent storms at that latitude. Ultimately, tornadic storms did develop near the Red River.



The 3-hour model forecast valid at 5 pm CDT (left), produced by the NWS Norman version of the WRF model, predicted very accurately the radar echoes (right) that would be produced by numerous discrete thunderstorms developed from border to border in Oklahoma, and across the Oklahoma City area.

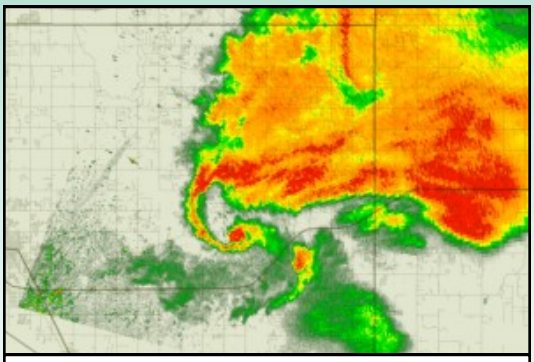
Close Call

As a significant tornado set down in southeast Norman, an Oklahoma Mesonet station located in the National Weather Center parking lot measured a sudden pressure drop of 4 millibars. This was followed by a measured wind gust of 70 mph from the northwest as the tornado developed less than one mile southeast of the station.

Senior Forecaster, Chris Sohl, snapped this picture of a funnel cloud over the National Weather Center when craning his neck to look nearly straight up from a window in the Forecast Office's Operations Area. In the same room, forecasters were continually issuing updated statements and warnings pertaining to numerous thunderstorms and tornadoes occurring throughout Oklahoma and western north Texas. The funnel seen here became a tornado moments later, and became a deadly, EF-4 tornado, as it tracked east of the National Weather Center.

Note: If the tornado had struck the National Weather Center or if the Forecast Office staff had taken shelter, warning services would have continue as the Tulsa Forecast Office would have assumed responsibility.

The radar known as OU-PRIME, located near the National Weather Center, captured a tornadic supercell in unprecedented high resolution, according to the director of the University of Oklahoma's Atmospheric Radar Research Center, Dr. Robert D. Palmer. The radar for use by University students and faculty.



Radar reflectivity image from OU-PRIME showing a long track supercell as a violent tornado was ongoing near Lake Thunderbird east of Norman, OK. The tornado is located in the ball of high reflectivity at the end of the traditional hook echo, while the comma shaped echo farther southeast of the tornado

Editor's Note

Warning Coordination Meteorologist, Rick Smith, calls people to the window, craning their view directly up into the funnel that lands at the NWC. This soon becomes a damaging tornado east, while it sounds as though the rear flank downdraft has opened a hole on the next floor, and I hear debris rattling over my head. Lights flicker for minutes. Yet the warning forecasters never left their seats, and our services never skipped a beat. One of moments I'll remember.

Patrick Burke
Newsletter Editor

My Facebook Status, written just after my shift ended on May 10, 2010.

By the Numbers

More on May 10th

- At least one NWS Norman Tornado Warning was in effect continuously for 7 hours and 23 minutes.
- From 5:00 pm to 7:41 pm CDT, there was at least one tornado occurring in Oklahoma every minute. 42 different tornadoes occurred within this time.
- Between 5:33 PM and 5:59 PM, there were between three and five tornadoes occurring simultaneously every minute. This included a portion of the life cycle of 13 different tornadoes, including both EF4 tornadoes and two EF3 tornadoes.
- Tornadoes literally occurred from border to border in Oklahoma, in a 200 mile corridor from the Kansas state line to just north of the Red River.
- NWS Norman issued a total of 31 Tornado Warnings (TOR), 19 Severe Thunderstorm Warnings (SVR), 95 Severe Weather Statements (SVS), 3 Warning Decision Updates (AWU), 12 Regional Weather Discussions (NOW) and 8 multimedia weather briefings during the outbreak.

Trivia

Outbreak Bolstered Tornado Clount

Up until May 10th, Oklahoma had experienced its lowest tornado count to begin a year. There were only 3 tornadoes observed in the state from January 1st to May 9th. The next day saw 55 tornadoes rip across the Sooner state, and the total for the year will be 101.

Media & Partners

Warning Coordination Meteorologist, Rick Smith, participated in several interviews with **'NewsOK'**, which is the online version of the Daily Oklahoman newspaper. During the event, Rick also provided three live interviews with **The Weather Channel** and an interview with **Telemundo** focusing on preparedness. NWS Norman provided many other interviews to the media prior to and during this event.

The event also helped to further strengthen working relationships with local, state and federal emergency management partners, including FEMA.

Breaking New Ground

The event provided the first real test of our ability to provide detailed focused threat information based solely on expert forecasts versus traditional warnings that are based primarily on detection of an ongoing threat. Our ability to warn of specific threats hours in advance was directly tied to May 10th being a very predictable event with strong, well defined ingredients for a tornado outbreak that were consistently forecast by successive model runs and confirmed through observation. Such highly confident forecasts at lead times of one or more hours will be a greater challenge during most weather events, but is the subject of the National Weather Service initiative to develop "Warn on Forecast" capability.

May 10: A Forecaster's Experience

Anticipation (May 4-9)

By Patrick Burke
General Forecaster

On Wednesday, May 5th, 2010, I began a set of evening shifts (4 PM-12 AM) that would last through the next Tuesday. The forecaster I relieved that afternoon briefed me on the prevailing weather pattern. The main topic was a small but well-defined system forecast by long-range numerical model forecasts to impact the Southern Plains on or around Monday, May 10th.

The event certainly appeared worthy of discussion in our public forecasts. Still, the fine details that turn an ordinary severe weather event into an extraordinary severe weather outbreak usually don't become evident until much closer to the time of the event. What ingredients would or would not fall into place? I mentioned the forecast in "possible" terms to my wife, a non meteorologist, the next day.

The "run-to-run" consistency that we saw in the forecast models starting May 4th, when Mike Branick had introduced a possible May 10th event to our vocabulary, led the National Weather Service Office in Norman to elevate our public message before the weekend. The word, "possible" disappeared from our products, replaced by safety and preparedness information. I kept planting ideas in my wife's head that she would need to be especially aware of the weather on Monday, and I began to contact other family members, too.

When on Saturday evening the collective weather information was still pointing at much the same thing, I wondered what I could add to the message appearing in our forecasts, including on our web page. I tried to mentally fast forward to Monday afternoon. Models predicted storms moving at 45 miles per hour. I envisioned fast moving supercells, possibly or even probably tornadic. The storm motions would likely yield less overall lead time on Tornado Warnings, even despite our best efforts. I conveyed these thoughts in an updated Hazardous Weather Outlook.

When I arrived home from work just after midnight on May 9th, I initiated what would be a series of e-mails with a group of family and friends living in Oklahoma and Kansas. Later that day I spoke again with my wife. I recalled her having mentioned plans to be in downtown Oklahoma City attending a meeting on Monday. Though it made me nervous, we agreed that she would leave the meeting immediately upon its conclusion at 4:00 PM, and drive directly home.

While deficiencies remain in our knowledge of exactly how tornadoes form, everything that appeared in the data on Sunday evening remained consistent with previous forecasts, and suggested that tornadoes were likely, and that strong or violent tornadoes were possible, if not likely. Seemingly, the only significant question that remained was the southern extent of thunderstorm development. The greatest lift to initiate storms would pass through northern Oklahoma, and several runs of respected forecast models did not produce any precipitation in central and especially southern Oklahoma or north Texas. The models had, however, trended toward a slightly deeper trough producing broad lift down to the latitude of Ardmore. I was confident the cap would be weak and breakable,and with rapidly returning moisture I became very confident that thunderstorms would form down to the latitude of Norman, OK, and likely to the latitude of Ardmore.

My expectations had become nearly as high as they can be 18 hours before an event. Those of us on shift Sunday night discussed, but stopped short of using, the word "outbreak" in our public products, feeling, instead, that the word should be reserved for possible use the next day. We did initiate multimedia briefings on our enhanced web page. Christine Riley discussed severe weather timing and safety. We felt it was important for people to ask themselves, "Based on where I will be at 4 to 6 PM on Monday, how will I receive tornado warnings, and where will I take shelter?" Also, when creating the hazardous weather outlook graphic that night, I wondered if someone in the Day 2 Slight Risk area would be less concerned than someone in the Day 2 Moderate Risk area. Within the graphic's text I tried to emphasize that the risk areas corresponded to varying numbers of storms, but that *each* storm in *each* risk area would be equally dangerous. As is always the case, part of our intent is for our media partners to recognize the urgency and pass these messages to a wider audience.

Once home that night I watched the Storm Prediction Center Day 1 Convective Outlook come out at 1 AM with a High Risk for part of central and northeast Oklahoma. I agreed in principle with the way the outlook was drawn. I did, however, have a growing concern for areas just outside the High Risk, and very close to home here in Norman. Since I had become convinced we would have storm initiation this far south, I reasoned that instability would be greater here, owing to warmer temperature and greater moisture, and that low-level wind shear would be equally incredible as in the High Risk area. I posted my thoughts to a storm chaser discussion group and sent an updated e-mail message to family and friends.

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Build Up (Early May 10)

There is a certain tingling sensation that I, and maybe other meteorologists have come to recognize in Oklahoma when it is "one of those days." I think that we are not often convinced that tornadoes will automatically be the outcome, and when we are convinced, such as on May 10th, we experience a prolonged period of adrenaline release that heightens the senses and makes us very aware of our every move and decision.

This particular time, though, was unique, in that I was fairly certain that significant tornadic storms would affect a great deal of our forecast area from beginning to end of my particular forecast shift. In my eigth year career I had not experienced anticipation on that large a scale, and I was glad to have rested so well. I woke up ready for a fight.

As I often do in the spring, my first action out of bed was to poke my fingers through the blinds, making an opening through which I could quickly survey of the sky. Its character was as I had expected, broken or nearly overcast with low clouds rushing northward at a healthy pace. It was around 11:00 AM. I moved to the kitchen table with my laptop computer and saw the High Risk area had expanded a little farther southwestward into the Oklahoma City area. I surveyed some other weather data, but I didn't want to start over-thinking the situation. I had been watching this day's weather approach for 5 days on shift, so I was already very aware of what was known (yes, there will be tornadoes nearby this afternoon) and what was unknowable (which specific communities will be in the paths?).

I sent my wife text messages to remind her how significant today would be. Later she was able to call me during her lunch break. She asked where I would chase if I were off work and chasing storms that day. In all seriousness, I said Moore, OK, but I also told her and others that I did not recommend anyone chasing storms that day. With storms moving at "warp speed," I would have chosen to watch from my front yard, ready to dive into our designated tornado closet at any moment. By 2:00 PM thunderstorms were forming in northwest Oklahoma, and heightened coverage on television had begun. I sent another updated e-mail to my local family and friends. The first Tornado Warnings were issued in northern Oklahoma. My last action before leaving home around 3:20 PM was to fill our master bedroom closet with blankets and pillows should my wife need to take cover.

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I believe I wore sunglasses on the drive into work. It was bright enough, but clouds were beginning to dominate the western sky. I knew I would find a full house inside the Forecast Office, with extra help from managers, students, and forecasters staying beyond the end of their shift to work overtime. The Warning Decision Training Branch of the National Weather Service often staffs a desk at the back of the Operations floor where they make phone calls to trained weather spotters. Every desk was occupied. Carrying my lunch bag toward the break room I overheard our Science Officer calmly directing some of his family to prepare their tornado safe room with blankets and pillows just in case a storm should threaten them. You would not hear things like that during just any Tornado Watch on any day.

It was clear that storms had begun to form west of the large metropolitan area, and that Oklahoma City would be threatened during rush hour traffic, as the office had been advertising since around noon. We had two Senior Forecasters acting as event co-coordinators that day, something that I would find to be very helpful over the course of the event. This gave me more chances to catch one of them for advice or help adjusting radar settings or help getting the details of certain spotter reports. We set up three warning sectors, and I was to immediately become warning forecaster for southern Oklahoma and western north Texas. I took a seat at the only workstation available to me, one vacated by an Intern who would be venturing outside to launch our evening weather balloon. The desk was conveniently located near our public service desk where spotter reports arrive via phone and amateur radio. The top row of televisions on our Situational Awareness Display System (SADS) was tuned to Oklahoma City stations, while the mini-SADS just behind my seat was tuned to coverage related to my warning sector in the Red River, Texoma-land area. After setup, I began to monitor both my sector and central Oklahoma.

Soon I made the decision to clear any central Oklahoma data I had been monitoring so that I could devote full attention to radar echoes that were growing from northwest of Wichita Falls up through Duncan. I darted a glance at the clock, 4:15 pm. My wife should have left Oklahoma City at 4:00 pm. Did she? That Canadian County storm and others forming toward Chickasha would become trouble from Norman to Oklahoma City in a hurry. I knew that I was about to become busy, so I took this moment to reiterate to my wife the importance of not getting caught on the road. For that matter, my mother works in Yukon, and was actually closer to the growing storms. I texted both of them with the simplest, most clear-cut message I could think of, "GET HOME NOW !"

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I turned back to my workstation, proactively flipping through each radar scan: up and down in elevation; down and up; back in time, forward in time; toggling between reflectivity and velocity; running time-lapse loops. All of this is second nature. In fact, this is the easy part. But I was interrupted. My phone buzzed with a text. It was from my mother, "Did you say now?" "Unbelievable!", I thought, "I've been telling you about this day in explicit terms since last week." I texted back, "NOW!" I went back to interrogating radar data and taking in all of the audio information around me. We don't often talk about how important sounds are in the warning environment. From a small speaker at my workstation is the sound of whatever Oklahoma City television station we have on the center screen at the time (this varies depending on the most pertinent coverage). Behind me is the television feed from southern Oklahoma, and our Warning Coordination Meteorologist passing along information from online feeds of storm chaser and storm spotter groups. Our workstations ding routinely to alert us of an important product or observation that deserves our attention. Around the room 2 or 3 people at a time may be holding a phone conversation, any one of which could delve out information regarding a storm that I am watching.

Several minutes later my cell phone buzzes again; my wife is calling me. "You can't send scary messages like that. What do you mean, 'now'?" She doesn't sound like she is driving. My mind is racing. I note the time, 4:31 PM. Quickly she explains, "The meeting is over, but I was talking to some people. I'm ready to leave, but what should I do?" I'm nearly flabbergasted at this; we had earlier agreed she would have left as close to 4:00 PM as possible. But there is no time to waste on argument, so I remain focused and ask her to give me one minute. I pull up the central Oklahoma radar and place a timing tool on the movement of a couple different thunderstorms approaching the metro. I tell her,

"If you leave right now and go directly home, I am sure you will beat the storm. But if you become slowed by gridlock traffic for any reason at all, you absolutely have to call me back. Let me know when you make it home."

At 4:51 PM I issued a severe thunderstorm warning for a broken line of storms between Wichita Falls and Duncan. About the same time I looked up at the SADS to see a very familiar scene, the Interstate 40 exit at Morgan Road in Canadian County, near where I grew up. Chasers were filming a snaky tornado that looked to be no more than 5 miles west of that intersection and crossing the picture from left to right. It was backlit by the sun and looked very impressive. This would have been very near to where my mother works, but I knew she would have driven in the opposite direction of the tornado to get home. I didn't worry too much about her, specifically, but there were plenty of other people threatened, many of them being family and friends. I had to bring my gaze back down to the workstation, but what I could gather from the chatter that surrounded me told me the Yukon tornado had not caused serious damage.

Starting with the Yukon tornado, the May 10th outbreak would become defined by a series of rapid-fire events over the next two hours. Information was entering the office via numerous reporting methods and also leaving the office through our varied warning products - *much faster than I had ever seen*. Aside from the warning forecasters and coordinators, nearly everyone in the room was on the phone continually. Shouting across the room, which is possible in some events, was not practical over the drone of television feeds and the dialogue of a dozen or more employees. So there was a lot of hurried scuttling back and forth as people passed reports on to the appropriate warning forecasters. Amidst all this, I had drawn a challenging sector. The first signature that really stood out was that of strong rotational shear in Stephens County, but with rotation in a clockwise or anticyclonic direction. This is opposite of how most tornadoes form, but was worrisome enough to follow it closely. When the next scan arrived just a few minutes later the shear signature had persisted while also growing taller and stronger. A cyclonic shear of this magnitude in this environment would automatically warrant a tornado warning. Animations did not seem to reveal a splitting supercell, which seemed the most likely process to have formed such strong anticyclonic shear, but at least this hypothesis was consistent with the velocity signature's location - northeast of one particular rain and hail core and moving northward compared to the traditional supercells. I grabbed one of the coordinators walking by, had a very quick consultation, and took action at 5:25 PM. The first Tornado Warning I issued on May 10th was for a rare anticyclonic tornado on a left moving supercell. A tornado did form, and caused EF1 damage near Bray in northeast Stephens County.

At this point I worked to stay focused on the upswing in activity over my sector while tornado reports escalated throughout Oklahoma City. I would hear, "Tornado in Bethany," followed by "Tornado in Moore," followed by, "Tornado at I-35 and Indian Hills Road near Norman." There weren't many live images of tornadoes on television during that time, and I started to become confused as to what was happening in

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the metro just miles from our office. How large or well formed were these tornadoes? A strong tornado moving through just one of those Oklahoma City suburbs would be a huge story and produce a lot of damage, and yet according to what I had heard there were tornadoes occurring in *all* of those suburbs at once! My wife texted around this time to say she had arrived home safely. I overheard some talk of extending a tornado warning down to include Norman, covering both the tornado at Indian Hills Road and the likelihood that growing storms would soon produce tornadoes near Norman proper.

We have west facing windows to either side of the SADS, and I began to steal glances at a greater frequency. It was windy. The sky had grown somewhat darker with cloud cover, but there were still hints of sunlight letting me know it was not overcast. Yet, there was such little contrast to the cloud features that it seemed my hopes of sighting some storm structure were in vain. I concentrated on southern Oklahoma, tracking the anticyclonic signature, and inspecting whether any other storms required new Tornado Warnings. In my peripheral vision I made subtle note of our Warning Coordination Meteorologist, Rick Smith, walking over to the west facing windows. He said something that caught my attention, and then said it again, louder, "We've got a funnel forming right here! I mean just right here. Above the building!" Rick had bent his knees and craned his neck while pointing to where he was looking, nearly straight up. There was the sound of scampering as, like so many iron filings drawn by a magnet, anyone not tied to a phone swept over to Rick's side and peered upward. Senior Forecaster, Chris Sohl, who was carrying a camera that we use to document operations during significant events, snapped a picture. I was curious and still a little confused; was this tornado forming in the traditional supercell fashion and why hadn't anyone mentioned a mesocyclone approaching the National Weather Center? But most of all I was fixed on the job at hand. The wind started to change directions and whip around aggressively. If a tornado was forming at the building, we were certainly in some danger, but I reasoned that with such fast storm motion the tornado would not become fully developed until it moved past us. My most immediate concern was not for our safety at the Forecast Office, but for anyone who might be just outside the building or leaving it. I yelled for one of the other forecasters stationed near our building radio handset to alert security and have them follow tornado safety procedures.

Just then the storm's rear flank downdraft hit, and the wind direction steadied from the west or northwest while the speed become very strong. Trees were rolling back and forth, and the sound of the wind invaded the operations floor. Somewhere over my head and a little back there came an unexpected and unmistakable sound of the wind sweeping gravel, grit, or bits of "stuff" along a hard surface. Was this happening on the next floor of the building, or in the crawl spaces between floors?" I would learn later that there were no broken windows, so it is unclear where exactly the wind was able to enter the building like that. The scratchy scraping sound lasted maybe 10 or 15 seconds, and an Oklahoma Mesonet anemometer in the parking lot measured a gust of at least 70 mph.

The lights flickered and power fluctuated ominously for the next few minutes. The Forecast Office in Tulsa was, no doubt, dealing with just as much weather as we were, and we would have hated to ask them to take over. As the storm kept moving, winds decreased, power seemed to stabilize, and I started to let my anxiety about the power down slowly. Just then on the center screen of the SADS, KWTV switched to a helicopter image. A tall, thick, slightly arching gray tornado extended from cloud base to the ground… or to the water. I kind of knew before hearing it confirmed by the audio, but the tornado was planted on Lake Thunderbird just east of Norman. The tornado's width did not seem to decrease at all from cloud base to the earth's surface. This was a drill press, a very serious tornado backlit by a hazy, brownish-yellow sky. For me this few seconds of video became the iconic weather (not damage) image of May 10th. I couldn't believe this tornado had started at the National Weather Center, and I prayed for those in its path.

I received a text from my mother. She had heard the National Weather Center was damaged and that windows were broken. Although I didn't know for sure at the time, the report of damage was not true, and I assured her that I was fine. Now that storms had passed the office it was very unlikely that we would be hit again. I knew my family members were home safe, and the rest of the evening felt a bit more like the severe weather outbreaks that I am accustomed to working. The task remained very challenging, though, as storms tracked through southern Oklahoma at long range from our individual radars. Reports from trained spotters, including those forwarded to us by the National Weather Service Office in Fort Worth, were invaluable. I issued Tornado Warnings across Carter County between 5:49 PM and 7:15 PM. I was particularly concerned for the town of Lone Grove, which had experienced a devastating tornado in February 2009, and for the city of Ardmore. A large tornado did strike near Lone Grove, causing EF3 damage to at least 4 mobile homes and 1 foundation home. Fortunately, no serious injuries were reported, and the tornado did not strike the

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town directly. Softball size hail was reported ten miles northwest of Marietta, but storms in far southeast Oklahoma produced only short-lived tornadoes associated with EF0 to EF1 damage. People around me worked throughout the evening to sort damage reports so we could give accurate preliminary accounts to the media, and also to damage survey teams that would form the next morning. Given the quick motion of the upper level weather system, the last severe storm exited Bryan County, our southeastern-most county, by 10:30 PM. With the late action being limited in areal coverage and intensity, the number of student employees, managers, and overtime shift workers had slowly dwindled during the final two hours of the event. By 11 PM, we were left with the usual complement of three meteorologists. I got up to stretch my legs and warmed up some pizza the office had ordered a few hours back. The anticipation was over. For the first time in six days I was able to breathe out and not think forward to May 10th. I struggled to come up with something to say or do. What would I normally be doing at this time of night? I said, "Hi Christine," realizing I had been seated about six feet from her for seven hours and had probably not spoken with her once.

When I went home, although I knew it had been a terrible day for many Oklahomans, I felt peaceful. It was cooler and drier outside, and winds were nearly calm. I felt as though we did everything we could to prepare people for the tornado outbreak, and many lives were likely changed or saved by our services. I felt good about what I do, and about being part of a team with a focused mission to serve. While some would say events like the tenth of May must be the hardest to work, those are the days on which I thrive, and during which the National Weather Service and our partners shine.

Warning Response

My only disappointment with our warning performance on May tenth was this: both my wife and my mother returned my most strongly-worded personal warning with questions rather than action. It may seem harsh to be disappointed at this, but let me explain. Social research is starting to tell us that a person's first reaction to a Tornado Warning is *not* to take shelter, it is to seek confirmation that they are actually threatened. Meteorologists cringe at this because not all Tornado Warnings are equal, and the seconds or minutes that you spend seeking confirmation may be the same critical seconds or minutes in which you needed to get yourself and others to a safe place. In my case, these were the two people who probably know me and can gauge my statements better than anyone on earth. I had been telling them about this event for several days, and had told them very accurately what time the danger would develop. I had never before told them to drop what they were doing and hurry home. I thought their confidence in me and the strength of my message would cause them to take action. I thought my text reminder at 4:15 PM on Monday should have been equivalent to checking your purse for airline tickets during your drive to the airport. You are already on your way, and you know you put the tickets in there, but it just doesn't hurt to look again and make sure. Instead, my mother and wife responded, respectively, with questions that amounted to, "Do you really mean it?" and "What do you mean? How bad is it?" This makes me think we have a long way to go toward maximizing public response to weather warnings. We need to know more about how people interpret information and how they make decisions about self preservation. While advances in technology and meteorology will help a little bit, it is likely that advances in social science and adjusting our warning information to fit human behavior will go farther toward our goal of saving lives and property in the coming decades. Knowing that another May 10th could be just around the corner, I look forward to the challenge.

Thank You to Everyone Who Helped People Receive Weather and Safety Information on May 10, 2010

Thanks for Reading!

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